DOCUMENT RESUME

ED 440 576 HE 032 791

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TITLE	The Human Capital Liabilities of Underrepresented Minorities in Pursuit of Science, Mathematics, and Engineering Doctoral Degrees.
INSTITUTION	Spencer Foundation, Chicago, IL.; National Center for Postsecondary Improvement, Stanford, CA.
SPONS AGENCY	Office of Educational Research and Improvement (ED), Washington, DC.
REPORT NO	NCPI-TR-2-13
PUB DATE	1999-00-00
NOTE	21p.; A version of this paper appears on the Web site of "Making Strides," a publication of the American Association for the Advancement of Science: http://ehrweb.aaas.org/mge/Archives/2/Nettles.html.
CONTRACT	R309A60001
AVAILABLE FROM	National Center for Postsecondary Improvement, Stanford University, School of Education, 520 Galvez Mall, 508 CERAS, Stanford, CA 94305-3084 ($3.50). Tel: 650-723-7724; Fax: 650-725-3936; Web site: http://ncpi.stanford.edu.
PUB TYPE	Numerical/Quantitative Data (110) -- Reports - Research (143)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Academic Achievement; American Indians; Asian American Students; Black Students; Diversity (Student); *Doctoral Degrees; *Engineering Education; Graduate Students; Graduate Study; Higher Education; Hispanic American Students; *Human Capital; *Mathematics Education; *Minority Groups; Racial Differences; Racial Factors; *Science Education; Sex Differences; Socioeconomic Status; Student Characteristics; Student Experience; Tables (Data)
IDENTIFIERS	African Americans; American Indian Students; Native Americans

ABSTRACT

This national study of doctoral students examined various components of human capital and their effects upon doctoral students' experiences and achievement. Participants were 13,160 graduate students in 11 fields from 21 universities, including all African American, Asian American, Hispanic American, and Native American students, 300 white students, and one-half of all international students in the selected fields. Students completed the Survey of Doctoral Student Experiences, Performance, and Achievement, which examined demographic differences, backgrounds, finances, experiences, progress, and performance, and the relationship of these variables to the quality of students' experiences and performance in doctoral programs. Results indicated clear human capital differences between major fields and among racial groups. Engineering students in each ethnic group had more human capital than science/mathematics students. They had parents with higher levels of education and occupation, had attended the most selective colleges and universities, had higher college grades and test scores, and had had more work experience before entering doctoral programs. For the four racial and ethic groups, white and Asian students had the greatest, and African Americans had the least, amount of human capital and research

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productivity. Doctoral grade point average was of little use for discriminating by major field or race; research productivity yielded greater discrimination. (Contains 11 tables.) (SM)

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The Human Capital Liabilities of Underrepresented Minorities in Pursuit of Science, Mathematics, and Engineering Doctoral Degrees

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The work reported herein was supported in part by the Educational Research and Development Center program, agreement number R309A60001, CFDA 84.309A, as administered by the Office of Educational Research and Improvement (OERI), U.S. Department of Education. The findings and opinions expressed in the report do not reflect the position or policies of OERI or the U.S. Department of Education. NCPI Technical Report Number 2-13.

HE 032 791

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A version of this paper also appears on the website of Making Strides, *a publication of the American Association for the Advancement of Science (http://ehrweb.aaas.org/mge/Archives/2/Nettles.html)*

Introduction

Throughout their lifetimes, students accumulate assets in the form of knowledge and cultural and social experiences that, when taken together, become their human capital. Their social-class standing and the quality of their schooling and non-school related activities during childhood and adolescence contribute to their asset accumulation by providing access to knowledge and opportunities for social and cultural involvement in society. As students progress through successive stages of life and education, they build more capital for use in future stages of life and education. Higher social-class status and better quality of schooling allow students to develop and accumulate more human capital; to gain greater access to high-quality colleges, universities, and doctoral programs; and to be better prepared to succeed in doctoral programs.

Human capital development may be a critical element in the race group differences that we observe in higher education and in the workforce. The greater the extent to which important components of human capital and racial differences can be identified, the greater the likelihood that colleges and universities will be able to attack them as barriers to equality in access, performance and achievement.

This paper presents some of the findings from a national study of doctoral students sponsored by the Spencer Foundation and the National Center for Postsecondary Improvement; the study examined many components of human capital and their effects upon student experiences and achievement. The research was aimed toward assessing the backgrounds, finances, experiences, progress, and performance of doctoral students, and the relationship of their backgrounds and finances to the quality of their experiences and performance in doctoral programs. The research was also structured to identify race, sex, social class, and other demographic distinctions among doctoral students and to show how these differences relate to differences in students' progress and performance.

The study grew out of a need to fill the existing void in data and information about human capital assets of doctoral students, such as their current and past family and personal characteristics and educational processes and experiences. The necessary data and information also include the types of support students have received as well as their satisfaction, performance, opinions, and behaviors while pursuing their doctoral degrees. Much is known about people who seek to enter graduate programs through the Graduate Record Examinations Board's Background Information Questionnaire (BIQ), which accompanies the Graduate Record Examination (GRE). Even more is known about students when they successfully complete doctoral programs through the National Research Council's (NRC) Survey of Earned Doctorates, and later on in their careers through the NRC Survey of Doctoral Recipients. Very little is known, however, about doctoral students while they are in the process of pursuing their doctoral degrees. The

GRE/BIQ is limited because no effort is ever devoted to following up with the examinees to identify if they apply, where they apply, where they are accepted, whether they go on to graduate school, and if so, where they go. The two NRC surveys include only those students who successfully complete their doctoral programs, and even then not much is asked about their pre-collegiate and collegiate experiences, or about their experiences during their doctoral programs.

The low number of African Americans and Hispanics enrolled in U.S. graduate programs and receiving doctoral degrees is very well documented. African American and Hispanic doctoral students are underrepresented in every field; they are most severely underrepresented in the fields of science, mathematics, and engineering, and among the nation's highest quality doctoral degree programs. Increasing their representation, however, is only part of the challenge that the nation's leading graduate schools are facing.

In addition to being underrepresented, African American and Hispanic students who are enrolled in doctoral programs may also be lagging behind their majority and Asian contemporaries in human capital in areas such as their background characteristics and their academic and social preparation for graduate school. They may also be lagging behind in funding support, quality of experiences in doctoral programs, and rates of progress and performance in doctoral programs. It is very important for graduate school leaders to identify the areas of African American and Hispanic underrepresentation in doctoral programs and to develop strategies to increase their numbers and representation. Equally important is the need to identify gaps in progress, performance, and the quality of training and experiences. Once these gaps have been identified, educators, policymakers, and others will know where to direct their efforts toward improvement. One strategy may be to compensate for or eliminate altogether the deficits in human capital that African American and Hispanic students reveal.

Research Design and Method

This research was conducted to measure a number of factors, including many that are believed to be related to student progress and performance generally, and that are critical to the success of underrepresented minorities in both science and non-science oriented doctoral programs. This involved collecting information on the personal, family, social, and academic backgrounds, experiences, and performance of doctoral students prior to, during, and since undergraduate school. The most important performance emphases of the research were upon ascertaining the extent to which students are acquiring teaching and research skills, developing skills and experience of scholarly inquiry, publishing both independently and in collaboration with professors, and being socialized to succeed in a chosen profession after graduating.

The research has been conducted in collaboration with graduate deans and researchers at 21 of the nation's most prestigious doctoral granting universities. The universities are presented in Table 1. The research involved administering a survey to a diverse and representative sample of 13,160 doctoral students, spread among the 21 universities. To be selected as a participant in the study, students had to have completed at least one year of their doctoral program and be registered for at least six credit hours in the fall of 1996. Students also had to be enrolled in one of the following eleven fields of study: biological sciences, economics, education, engineering (includes chemical, electrical, and mechanical), English, history, mathematics, physical sciences (includes chemistry and physics), political science, psychology, and sociology. The sample was designed to select all of the African Americans, Asian Americans, Hispanics and Native Americans, three hundred whites (randomly selected), and one-half of the international students (randomly selected) enrolled in these eleven fields.

Table 1: Participating institutions in the study assessing underrepresented minority student experiences and success in doctoral programs

City University of New York	Teachers College
Clark Atlanta University	Temple University
Columbia University	University of California, Berkeley
Harvard University	University of California, Los Angeles
Howard University	University of Maryland at College Park
Indiana University	University of Michigan
New York University	University of North Carolina at Chapel Hill
Ohio State University	University of Texas at Austin
Princeton University	University of Wisconsin at Madison
Rutgers University	Vanderbilt University
Stanford University	

Each of the 13,160 students received the Survey of Doctoral Student Experiences, Performance, and Achievement (SDSEPA), which Nettles and Millett developed expressly for this study. The SDSEPA is a twenty-eight-page survey instrument that asks students to provide a variety of data and information about their backgrounds, current status and activities, academic progress and performance, attitudes, and behavior. The survey also gives students the opportunity to provide additional commentary on various subjects. Many students provided extensive commentary on enclosures that accompanied their survey responses. The SDSEPA also asked students to give researchers permission to retrieve their GRE files from the Educational Testing Service, which include score reports and BIQ responses. An overall response rate of 70 percent yielded 9,040 usable surveys for the analyses.

The results and findings reported in this paper are limited to the students in the survey who were identified by their institution and who identified themselves on the SDSEPA as pursuing doctorates in one of the biological or physical sciences, or in mathematics or engineering. Because the emphasis of this paper is upon underrepresented minorities in science, mathematics, and engineering in the United States, U.S. citizens are the focus of the analyses, and international students are not included. For the three-field grouping (science, math, and engineering) of U.S. citizens the sample size is 1,891. Overall race distribution is 114 African Americans (6 percent), 382 Asians (20 percent), 94 Hispanics (5 percent), and 1,301 whites (69 percent).

The analyses in this paper are descriptive. The data are presented with a narrative that describes the data for the four race groups of students by showing how they compare with each other on a variety of characteristics, experiences, and performance within and across the major fields. Approached in this way, working sequentially to assess and contrast groups on numerous variables, a profile emerges of typical doctoral students from each of the four race groups, and their accumulation of human capital and performance. When these profiles are contrasted, the reader should have an understanding of how students of different racial groups are alike and how they are different from one another. The reader might then proceed to the next step of imagining what actions could or should be taken to eliminate or compensate for the deficits in performance and progress that are identified among underrepresented minorities. The two principal questions to be addressed in the analyses are the following:

1. What are the similarities and differences in measures of human capital among doctoral students of various racial/ethnic groups?

2. What are the similarities and differences in the performance and development among doctoral students of various racial/ethnic groups?

Findings

This section presents the findings by describing (1) personal and academic backgrounds, (2) academic preparation and undergraduate experiences, (3) transitions from college to the doctoral programs, and (4) doctoral program experiences and performance of the science/mathematics and engineering doctoral students. For these analyses, biological science, physical science, and mathematics doctoral students are combined to make up one group called 'science and mathematics,' while the other group is called 'engineering.' In addition to contrasting science and mathematics students against engineers, overall, the analyses center upon racial group comparisons both within and across the two major fields.

Table 1A. Percent of doctoral students whose mother possesses at least a bachelor's degree (cell-specific sample sizes in brackets)

	Hispanic	Black	Asian	White
Science and Math	45.1 [71]	46.2 [78]	63.4 [224]	58.8 [955]
Engineering	56.5 [23]	51.5 [34]	59.2 [157]	60.5 [342]

Table 1B. Percent of doctoral students whose mother possesses a graduate or professional degree (cell-specific sample sizes in brackets)

	Hispanic	Black	Asian	White
Science and Math	28.2 [71]	24.3 [78]	29.4 [224]	30.0 [955]
Engineering	26.0 [23]	20.5 [34]	30.5 [157]	30.7 [342]

Background Characteristics

The background characteristics collected by the SDSEPA include the age, race, and sex of the doctoral students and the educational and occupational status of their parents. The focus in this paper is upon the socioeconomic background distinctions across the four race groups and two field groups. Parents' educational and occupational status are the indicators of socioeconomic status at least prior to entering college, but for most it also covers their college years, and for some it even represents their graduate school social class. Socioeconomic status measured in this way is a very important reflection of the exposure students have had to higher levels of education throughout their lives, and is perhaps a good indication of their own educational expectations and aspirations.

Parental Educational Attainment

Mother's Education: In both science/math and engineering, the mothers of Asians and whites are more likely to have at least a bachelor's degree than are the mothers of African Americans and Hispanics. In both fields, around 60 percent of the mothers of Asian and white doctoral students had completed at least a bachelors degree. In science and mathematics, 46 percent and 45 percent of the mothers of African Americans and Hispanics, respectively, had received at least a bachelor's degree. Approximately 56 percent of the mothers of Hispanic engineering doctoral students had completed a bachelor's degree, as had 52 percent of the mothers of African American engineering doctoral students. Moreover, about 30 percent of the mothers of white and Asian doctoral students in science and mathematics and in engineering had completed either a graduate or professional degree, as compared to 26 percent of the mothers of Hispanics and only 20 percent of the mothers of African Americans (See Table 1A and Table 1B).

Table 2A. Percent of doctoral students whose father possesses at least a bachelor's degree (cell-specific sample sizes in brackets)

	Hispanic	Black	Asian	White
Science and Math	59.2 [71]	35.1 [77]	74.9 [223]	71.0 [955]
Engineering	56.5 [23]	48.5 [33]	77.2 [158]	77.2 [342]

Table 2B. Percent of doctoral students whose father possesses a graduate or professional degree (cell-specific sample sizes in brackets)

	Hispanic	Black	Asian	White
Science and Math	43.7 [71]	17.6 [77]	46.1 [223]	50.6 [955]
Engineering	30.3 [23]	32.3 [33]	49.3 [158]	49.7 [342]

Father's Education: With the exception of African Americans in both major field groupings and Hispanics in engineering, fathers appear to have higher educational attainment than mothers, but the patterns remain the same as with mothers. As with doctoral students' mothers, the Hispanic and Black doctoral students are less likely than their Asian and white peers to have a father that has completed at least a Bachelor's degree. The difference is especially striking with respect to the fathers of African Americans compared to Asians and whites. The fathers of Asian and white doctoral students in the science/math field grouping are more than twice as likely to have a father with at least a bachelor's degree than Black counterparts. Over 70 percent of the fathers of Asian and white doctoral students in science and mathematics and over 77 percent in engineering have completed at least a bachelor's degree. Over 46 percent of the fathers of Asians and 50 percent of the fathers of white doctoral students in science and mathematics, and over 49 percent of both groups in engineering had completed a graduate or professional degree. About sixty percent of the fathers of Hispanic science and mathematics doctoral students and 57 percent in engineering had completed at least a bachelor's degree. Around 42 percent of the fathers of Hispanic doctoral students in sciences and mathematics and 31 percent in engineering had completed a graduate or professional degree. Thirty five percent of the fathers of African American science and mathematics doctoral students and 49 percent in engineering had completed at least a bachelor's degree. Only 17 percent of the fathers of African American doctoral students in science and mathematics and 33 percent in engineering had completed graduate or professional degrees (See Table 2A and Table 2B).

It is reasonably clear from these data that engineering doctoral students are more likely to have parents with higher degrees than their peers in science and mathematics. It is also clear that African Americans are least likely among the four race groups to have parents with the most advanced degrees.

Parental Occupational Status

Parents' occupation was measured using seven categories arranged in a hierarchical structure that is associated with both income and status. Examples of the types of occupations in the seven categories are 1) homemaker, 2) laborer etc., 3) truck driver etc., 4) electrician etc., 5) small business owner, 6) mid-level business person etc., and 7) business executive etc.

Mother's Occupation: African Americans lead the four race/ethnic groups in mothers' occupation. The mothers of African American science and mathematics and engineering doctoral students are most likely to be employed in the two highest employment categories (6 and 7 above)—53 percent of the mothers of science and mathematics students and 50 percent of the mothers of engineering students. Fifty-two percent of the mothers of Asian science and mathematics doctoral students and 43 percent of mothers of Asian engineering students fall into the highest two employment categories. Forty-six percent of the mothers of white science and mathematics students and 45 percent of the mothers of white engineering students fall into to the two highest employment categories. Of Hispanic students, 42 percent of the mothers of science and mathematics students and 39 percent of the mothers of engineering students are in these two categories.

The mothers of Asian doctoral students are most likely to be in the highest category—15 percent of the mothers of science and mathematics students and 17 percent of the mothers of engineering doctoral students.

At the other end of the scale, with the exception of African Americans, engineering doctoral students are more likely than their science and mathematics peers to have mothers who were homemakers. Forty-eight percent of the mothers of Hispanic engineering doctoral students were homemakers followed by 34 percent of Asians, 31 percent of whites, and only 6 percent of African Americans. Among mothers of science and mathematics doctoral students, 24 percent of the mothers of Hispanic students, 26 percent of the mothers of white students, 22 percent of the mothers of Asians, and 17 percent of the mothers of African American students were homemakers (See Table 3A and Table 3B).

Table 3A. Distribution of the homemaker status and the two highest categories of occupational status for science and math doctoral students (cell-specific percents in parentheses)

	Hispanic	Black	Asian	White
Homemaker	17 (23.9)	13 (16.9)	48 (21.7)	245 (25.8)
Mid-level Business Executive, etc.	21 (29.6)	35 (45.5)	84 (38.0)	358 (37.7)
Business Executive, etc.	9 (12.7)	6 (7.8)	33 (14.7)	76 (8.0)
Overall Sample Size	71	77	221	949

Table 3B. Distribution of the homemaker status and the two highest categories of occupational status for engineering doctoral students (cell-specific percents in parentheses)

	Hispanic	Black	Asian	White
Homemaker	11 (47.8)	2 (5.9)	53 (34.0)	104 (30.7)
Mid-level Business Executive, etc.	8 (34.8)	16 (47.1)	40 (25.6)	114 (33.6)
Business Executive, etc.	1 (4.3)	1 (2.9)	27 (17.3)	38 (11.2)
Overall Sample Size	23	34	156	339

Father's Occupation: Among science and mathematics and engineering doctoral students, the fathers of Asian and white doctoral students are most likely to have occupations in the highest categories, followed by the fathers of Hispanics and then African Americans. Among science and mathematics doctoral students, 72 percent of the fathers of Asian students, 68 percent of the fathers of white students, 60 percent of the fathers of Hispanic students, and 38 percent of the fathers of African American students fall within the highest two occupational categories. Similarly, among engineering doctoral students, 73 percent of the fathers of Asian students, 71 percent of the fathers of white students, 59 percent of the fathers of Hispanic students, and 46 percent of the fathers of African American students are employed in the top two occupational categories (See Table 4A and Table 4B).

Table 4A. Distribution of the homemaker status and the two highest categories of occupational status for science and math doctoral students (cell-specific percents in parentheses)

	Hispanic	Black	Asian	White
Homemaker	0 (0.0)	1 (1.3)	2 (0.9)	0 (0.0)
Mid-level Business Executive, etc.	17 (24.3)	19 (24.7)	60 (27.3)	285 (30.1)
Business Executive, etc.	25 (35.7)	10 (13.0)	99 (45.0)	360 (38.0)
Overall Sample Size	71	77	220	948

Table 4B. Distribution of the homemaker status and the two highest categories of occupational status for engineering doctoral students (cell-specific percents in parentheses)

	Hispanic	Black	Asian	White
Homemaker	1 (4.5)	0 (0.0)	0 (0.0)	0 (0.0)
Mid-level Business Executive, etc.	5 (22.7)	9 (28.1)	38 (24.2)	109 (32.2)
Business Executive, etc.	8 (36.4)	9 (28.1)	77 (49.0)	132 (39.1)
Overall Sample Size	23	34	157	338

Undergraduate Performance and Experiences

Undergraduate education is considered to be the place where students build the academic and social foundation for their doctoral program experiences. This study includes a variety of measures of students' undergraduate educational experiences that try to capture the quality of their experience, the match between their undergraduate preparation and their doctoral program, their academic performance, and their financial condition resulting from their undergraduate experience. The focus here will be upon the selectivity of undergraduate institution and grade point average. Together, these two measures provide a general indication of the quality of undergraduate preparation for doctoral students. The major field of study will be analyzed later in the paper.

Undergraduate Selectivity: Undergraduate selectivity of undergraduate institution is measured by the average SAT / ACT, the high school GPA, and class rank of the entering class of first-time, full-time freshmen, as calculated by *Barron's Guide*. Across the four race groups, engineering students attended more selective undergraduate colleges and universities than science and mathematics students. In general, Asian and white doctoral

Table 5A. Percent of doctoral students who attended a "highly or more selective" undergraduate institution (cell-specific sample sizes in parentheses)

	Hispanic	Black	Asian	White
Science and Math	40.4 [57]	16.9 [77]	56.9 [216]	51.5 [955]
Engineering	47.1 [17]	33.3 [33]	63.9 [155]	55.2 [339]

Table 5B. Percent of doctoral students who attended a "non and less competitive" undergraduate institution (cell-specific sample sizes in parentheses)

	Hispanic	Black	Asian	White
Science and Math	5.3 [57]	26.0 [77]	0.5 [216]	4.1 [955]
Engineering	5.9 [17]	24.2 [33]	1.3 [155]	3.8 [339]

students attended more selective undergraduate colleges than Hispanics and especially African Americans. Sixty-four percent of Asian engineering doctoral students attended the most competitive colleges and universities (SAT range from 625 to 800), followed by Asian science and mathematics students (57 percent), white engineering students (55 percent), and white science and mathematics students (52 percent).

A larger share of Hispanic students than African Americans attended the most selective colleges and universities. Over 47 percent of Hispanic engineering students, 40 percent of Hispanic science and mathematics students, 33 percent of African American engineering students, and 17 percent of African American science and mathematics students received their baccalaureate degrees from the nation's most selective colleges and universities. In addition, African American doctoral students are much more likely to have graduated from the least selective colleges and universities than are the other three racial groups. Over 25 percent of African American science and math doctoral students and 24 percent of the engineering doctoral students attended the least selective undergraduate colleges and universities, while across both fields, no more than six percent of any other race attended a Non- or Less-Competitive undergraduate institution (See Table 5A and Table 5B).

Undergraduate Grade Point Average: Undergraduate cumulative grade point averages (GPA) are reported on the typical four-point scale for all courses taken in college combined. As with regard to selectivity, engineering doctoral students overall report having a higher cumulative GPA than science and mathematics doctoral students. The exception is among African Americans, where science and mathematics students report a slightly higher GPA (3.4) than the engineering students (3.3). Among engi-

Table 6. Mean of undergraduate grade point average (standard deviations in parentheses and cell-specific sample sizes in brackets)

	Hispanic	Black	Asian	White
Science and Math	3.54 (0.32) [71]	3.40 (0.37) [80]	3.63 (0.33) [222]	3.64 (0.32) [952]
Engineering	3.76 (0.20) [23]	3.30 (0.36) [34]	3.69 (0.28) [157]	3.72 (0.27) [339]

neering doctoral students, the average undergraduate GPA for Hispanics was 3.76, followed by whites at 3.72, Asians at 3.69, and African Americans at 3.30. Among science and mathematics doctoral students the white and Asian doctoral students have the highest undergraduate GPAs at 3.64 and 3.63, respectively, followed by Hispanics at 3.54, and African Americans at 3.40. As with other background and undergraduate measures, African Americans have the lowest scores, while there does not seem to be much difference between Hispanics, Asians, and whites on undergraduate GPA in either field (See Table 6).

Preparation and Transition to Doctoral Programs

Three important measures of doctoral students' preparation for and transitions into graduate school are their GRE scores, the amount of time between their baccalaureate and entering a doctoral program, and the extent to which their undergraduate and graduate major fields match.

GRE Scores: Students in the sample reported their GRE Analytical, Verbal, and Quantitative scores on the SDSEPA. The analyses in this paper focus upon the race group average scores for the combined GRE Verbal and Quantitative components. The engineering students reported higher scores than their science and mathematics peers for each of the four race groups. In both fields, whites report the highest scores (1382 in engineering and 1367 in science and mathematics), followed by Asians (1358 in engineering and 1331 in science and mathematics), Hispanics (1265 in engineering and 1278 in science and mathematics), and African Americans (1252 in engineering and 1131 in science and mathematics). Looking at the Quantitative section of the GRE in isolation, a slightly different pattern emerges. In both fields, Asians have the highest average test scores (740 in Science and Math and 753 in Engineering), instead of whites (724 and 749, respectively). Hispanics (687 and 716, respectively) and African Americans (598 and 675, respectively) follow these two groups (See Table 7A and Table 7B).

Table 7A. Mean gre-quantitative test scores (standard deviations in parentheses and sample size in brackets)

	Hispanic	Black	Asian	White
Science and Math	687 (93) [45]	598 (119) [65]	740 (57) [187]	724 (64) [798]
Engineering	716 (71) [17]	675 (92) [28]	753 (47) [142]	749 (52) [284]

Table 7B. Mean gre-verbal test scores (standard deviations in parentheses and sample size in brackets)

	Hispanic	Black	Asian	White
Science and Math	591 (123) [46]	533 (111) [65]	591 (122) [189]	643 (94) [796]
Engineering	549 (112) [17]	577 (92) [28]	605 (115) [143]	633 (106) [280]

Time Off: Students in the science and mathematics disciplines appear to be more likely to enter their doctoral programs close to the time that they complete their bachelor's degree than do their engineering counterparts. Among the four race/ethnic groups in both science/math and engineering, Hispanics take the shortest time after completing their baccalaureate degree to enter their doctoral programs. The highest percent of Hispanic and white science and mathematics doctoral students (both 64 percent) go immediately into their doctoral programs, followed by Asians (60 percent) and African Americans (55 percent). Hispanics are most likely to enter a doctoral program within 4 years after obtaining their Bachelor's degree (96 percent), followed closely by whites (90 percent) and Asians (89 percent). African Americans are least likely to enter within 4 years (80 percent). The average amount of time off for science and mathematics doctoral students is 1.5 years for Hispanics, 1.7 years for whites, 1.88 years for Asians, and 3.92 years for African Americans (See Table 8A, Table 8B and Table 8D).

Experience as an employee in the workforce before entering a doctoral program may be valued more in the field of engineering than in science and mathematics among doctoral students. The percentage of students who enter immediately following undergraduate programs is lower among engineers. Forty-six percent of Hispanic engineering doctoral students go immediately into their doctoral programs after completing their bachelor's degrees, followed by 36 percent of whites, 36 percent of African Americans, and 25 percent of Asians. Around 96 percent of Hispanic engineering doctoral students enter their doctoral programs within four years of completing their bachelor's degrees, compared to 78 percent of Asians, 77 percent of whites and 71 percent of African Americans. The average time off for engineering doctoral students was 1.5 years for Hispanics, 2.82 years for Asians, 2.85 years for African Americans, and 2.89 years for whites (See Table 8A, Table 8C and Table 8D).

Table 8A. Percent of students who entered a doctoral program in less than one year (cell-specific sample sizes in parentheses)

	Hispanic	Black	Asian	White
Science and Math	63.4 [71]	55.0 [80]	60.3 [218]	63.1 [946]
Engineering	45.5 [22]	34.4 [32]	25.2 [147]	36.1 [330]

Table 8B. Distribution of years from bachelor's degree to beginning of doctoral program in science/math (cell-specific sample sizes in parentheses)

	Hispanic	Black	Asian	White
0-4 years	95.6 [64]	80.3 [61]	89.0 [174]	89.7 [849]
5 + years	4.4 [3]	19.7 [15]	11.0 [44]	10.3 [97]
Totals	100.0 [67]	100.0 [76]	100.0 [218]	100.0 [946]

Table 8C. Distribution of years from bachelor's degree to beginning of doctoral program in engineering (cell-specific sample sizes in parentheses)

	Hispanic	Black	Asian	White
0-4 years	95.5 [21]	71.9 [23]	79.0 [116]	78.2 [258]
5 + years	4.5 [1]	28.1 [9]	21.0 [31]	21.8 [72]
Totals	100.0 [22]	100.0 [32]	100.0 [147]	100.0 [330]

Table 8D. Mean years from bachelor's degree to beginning of doctoral program for science/math and engineering (standard deviations in parentheses and sample sizes in brackets)

	Hispanic	Black	Asian	White
Science and Math	1.54 (2.38) [67]	3.92 (6.48) [77]	1.88 (3.37) [220]	1.67 (3.77) [933]
Engineering	1.50 (1.87) [22]	2.85 (3.16) [34]	2.82 (3.31) [152]	2.89 (3.84) [333]

Table 9. Percent of doctoral students whose undergraduate major corresponds to their present doctoral field (cell-specific sample sizes in parentheses)

	Hispanic	Black	Asian	White
Science and Math	92.9 [70]	86.1 [79]	93.3 [224]	90.1 [956]
Engineering	95.7 [23]	85.3 [34]	91.7 [157]	85.3 [340]

Undergraduate and Graduate Major Field: Contrasting the undergraduate major with the graduate major fields provides a sense of the degree to which students' undergraduate experiences prepared them for their graduate programs. The vast majority of the students in both science and mathematics and engineering indicated having the same major fields at both levels and there appears to be little difference among the four race groups. Ninety-three percent of the Asian and Hispanic science and math doctoral students, 90 percent of the whites and 86 percent of the African Americans have the same fields at both the undergraduate and doctoral levels. Similarly, 96 percent of Hispanics, 92 percent of Asians, and 85 percent of African American and white engineering doctoral students have the same majors in their undergraduate and doctoral programs (See Table 9).

Doctoral Program Outcomes

While there are many measures included in the SDSPEA that may be used to assess the performance of doctoral students, the focus in this paper is on two general ones: 1) doctoral grade point average, and 2) research activities undertaken as a doctoral student. The former is important since grade point average is a common measure of how well a student has learned discipline-specific course information. Presumably, this information will be drawn upon as the student completes the dissertation as well as later in the career. The latter measures whether a student has completed three specific research activities that are intended to closely match the type of work that the student will perform in his/her future career.

Doctoral Grade Point Average: The differences in doctoral GPA are relatively small across fields and race groups. Doctoral grade point averages, however, are uniformly higher in engineering than in science and math, across all racial groups. Further, in both fields, African Americans report the lowest grade point average, though differences in absolute GPA seem relatively small. In science and math, Hispanics have the highest GPA at 3.65, followed by Asians (3.48), whites (3.45), and African Americans (3.41). In engineering, a similar pattern obtains, as Hispanics have the highest GPA at 3.78; Asians (3.76), whites (3.75), and African Americans (3.61) follow (See Table 10).

Table 10. Mean of doctoral grade point average (standard deviations in parentheses and cell-specific sample sizes in brackets)

	Hispanic	Black	Asian	White
Science and Math	3.65 (0.60) [71]	3.41 (0.76) [80]	3.48 (1.09) [222]	3.45 (1.15) [955]
Engineering	3.78 (0.13) [23]	3.61 (0.26) [34]	3.75 (0.42) [158]	3.76 (0.48) [342]

Doctoral Student Research Activities: With respect to research related activities undertaken as a doctoral student, large racial differences exist with respect to African Americans, but these racial differences, while quite large in the science and math field, are much smaller in engineering. One potentially important activity for doctoral students is presenting research papers at professional conferences. In the science and math field, a smaller percentage of African American and Hispanic doctoral students (21 percent and 16 percent, respectively) report having presented a research paper at a professional conference than Asian and white students (33 percent and 29 percent, respectively). In engineering, the differences are much smaller: Around 48 percent of Hispanics and 52 percent of African Americans, as compared to 53 percent of Asians and 59 percent of whites, have presented a research paper at a professional conference. While the white and Asian percentages remain higher than the Hispanic and African American percentages, the differences are much smaller than those in science and math, as reported above (See Table 11A and Table 11B).

Another important research activity is publishing academic papers. The first stage in publishing papers is submission to relevant journals. In the science and math field, there are substantial racial differences in who has submitted at least one research article for publication in a professional journal. Hispanics (49 percent), Asians (57 percent) and whites (54 percent) are all more than twice as likely as African Americans (24 percent) to have submitted an article. This suggests that African Americans are not receiving the opportunity to publish articles in professional journals, relative to the other races. The differences in engineering are much smaller and nearly non-existent. Whites lead the way with 73 percent reporting that they have submitted an article for publication; they are followed closely by African Americans (71 percent) and Asians (68 percent). Hispanic engineers are the least likely to have submitted an article at 60.9 percent.

With respect to actually publishing academic papers, the large racial differences in submission seen in science and math persist. For science and mathematics doctoral students, Hispanics (42 percent), whites (46 percent) and Asians (48 percent) are all more than twice as likely to have published a research article in a professional journal than African Americans (18 percent). Engineering shows a much different picture. Hispanics (52 percent) African Americans (47 percent), whites (47 percent) and Asians (45 percent) all report a similar frequency of publication (See Table 11A and Table 11B).

Table 11A. Percent of science/math doctoral students involved in various research activities (cell-specific sample sizes in brackets)

	Hispanic	Black	Asian	White
Presented paper at a research conference	21.1 [71]	16.2 [80]	33.0 [224]	28.8 [959]
Submitted a research article for publication	49.3 [71]	23.7 [80]	56.7 [224]	54.0 [959]
Published a research article in a professional journal	42.3 [71]	17.5 [80]	48.2 [224]	46.4 [959]

Table 11B. Percent of engineering doctoral students involved in various research activities (cell-specific sample sizes in brackets)

	Hispanic	Black	Asian	White
Presented paper at a research conference	47.8 [23]	52.9 [34]	53.2 [158]	59.1 [342]
Submitted a research article for publication	60.9 [23]	70.6 [34]	68.4 [158]	72.8 [342]
Published a research article in a professional journal	52.2 [23]	47.1 [34]	44.9 [158]	46.8 [342]

Conclusion

The analyses presented in this paper are an important first step toward identifying the gaps in both human capital and performance between underrepresented science/mathematics and engineering doctoral students and among four race groups of doctoral students. What emerges thus far is a rather strong impression that there are clearly human capital differences between the major fields and among the race groups. Engineering doctoral students have more human capital than their science/mathematics counterparts. As a group, engineering doctoral students have parents with a higher level of education and occupation, have attended the most selective colleges or universities, have a higher college grade point average, have higher GRE scores, and are more likely to have worked at a job between the time that they graduated from college and entered their doctoral programs than science/mathematics

students. Engineering doctoral students in each of the four race/ethnic groups have amassed a greater amount of human capital and research productivity than their science and mathematics counterparts.

Among the four race/ethnic groups, a human capital status hierarchy emerges in which white and Asian doctoral students possess the greatest amount of human capital and research productivity, followed by Hispanics and then African Americans. With the exception of mothers' occupational status, African American doctoral students present the lowest human capital and research productivity among the four race groups in each of the two major field groups. Doctoral grade point averages appear to be of little use for discriminating by major field or by race. The doctoral grade point average data presented in this paper suggest that both science/mathematics and engineering doctoral students are performing at a high level in their coursework. Research productivity may be a more important performance indicator for doctoral students than grades because they reflect the extent to which students are acquiring the research skills they need to progress in their careers. In contrast to doctoral grade point average, research productivity yields greater discrimination, and African Americans in science and mathematics are half as likely to publish research during their doctoral programs as their peers of other race groups and are half as likely to submit papers for publication. It is important to note that nearly three-quarters of African American doctoral students in engineering are submitting papers for publication and a higher percent are succeeding in publishing.

The actions that colleges and universities and African American science and mathematics doctoral students can take to address the lower success of African American students may be in part identified by examining more closely the African American engineering students and the factors that are of benefit to them. Another approach would be to address these students' deficits in human capital. In regression analyses in which numbers of papers published is the dependent variable, fathers' occupation emerges as the most important contributor to publishing: the higher the fathers' occupation, the higher the publication rate. Colleges and universities may target students whose fathers have lower occupations for encouragement and support for publishing. Both sex and race also emerge to be significant predictors of publishing, with women and African Americans being significantly less likely to publish. Even after controlling for human capital assets, African Americans and women need greater encouragement and support toward publishing in order to achieve equality of performance with their male and white, Asian, and Hispanic contemporaries. Thus, while human capital is very important for doctoral student performance, focusing upon the components of human capital alone is not sufficient. Colleges and universities will likely yield greater benefit from focusing upon improving the performance of women and African Americans.